# EXHIBIT B

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**Won et al.**

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(54) **CREATING AND/OR MANAGING META-DATA FOR DATA STORAGE DEVICES USING A PACKET SWITCH APPLIANCE**

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This patent is subject to a terminal disclaimer.

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**Related U.S. Application Data**

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(51) **Int. Cl.**
***H04L 12/28*** (2006.01)

(52) **U.S. Cl.**
USPC ..... **370/389**; 370/249; 370/392; 370/401; 370/395.41

(58) **Field of Classification Search**
None
See application file for complete search history.

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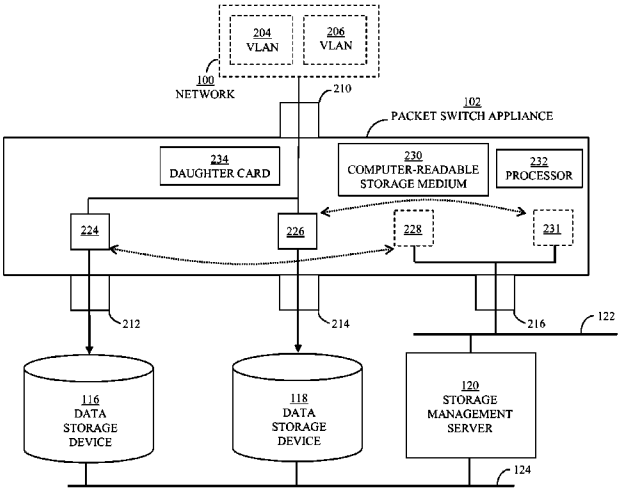
(57) **ABSTRACT**

A first instrument port of a packet switch appliance is connected to a first data storage device. A second port is configured as a first network port. A first meta-data tag is created for a first block of packets received through the first network port. The first block is sent to the first data storage device through the first instrument port. The first meta-data tag or copy is sent to the first data storage device and/or a storage management server. A second instrument port of the packet switch appliance is connected to a second data storage device. A second meta-data tag is created for a second block of packets received through the first network port. The second block is sent to the second data storage device through the second instrument port. The second meta-data tag or copy is sent to the second data storage device and/or the storage management server.

**39 Claims, 5 Drawing Sheets**



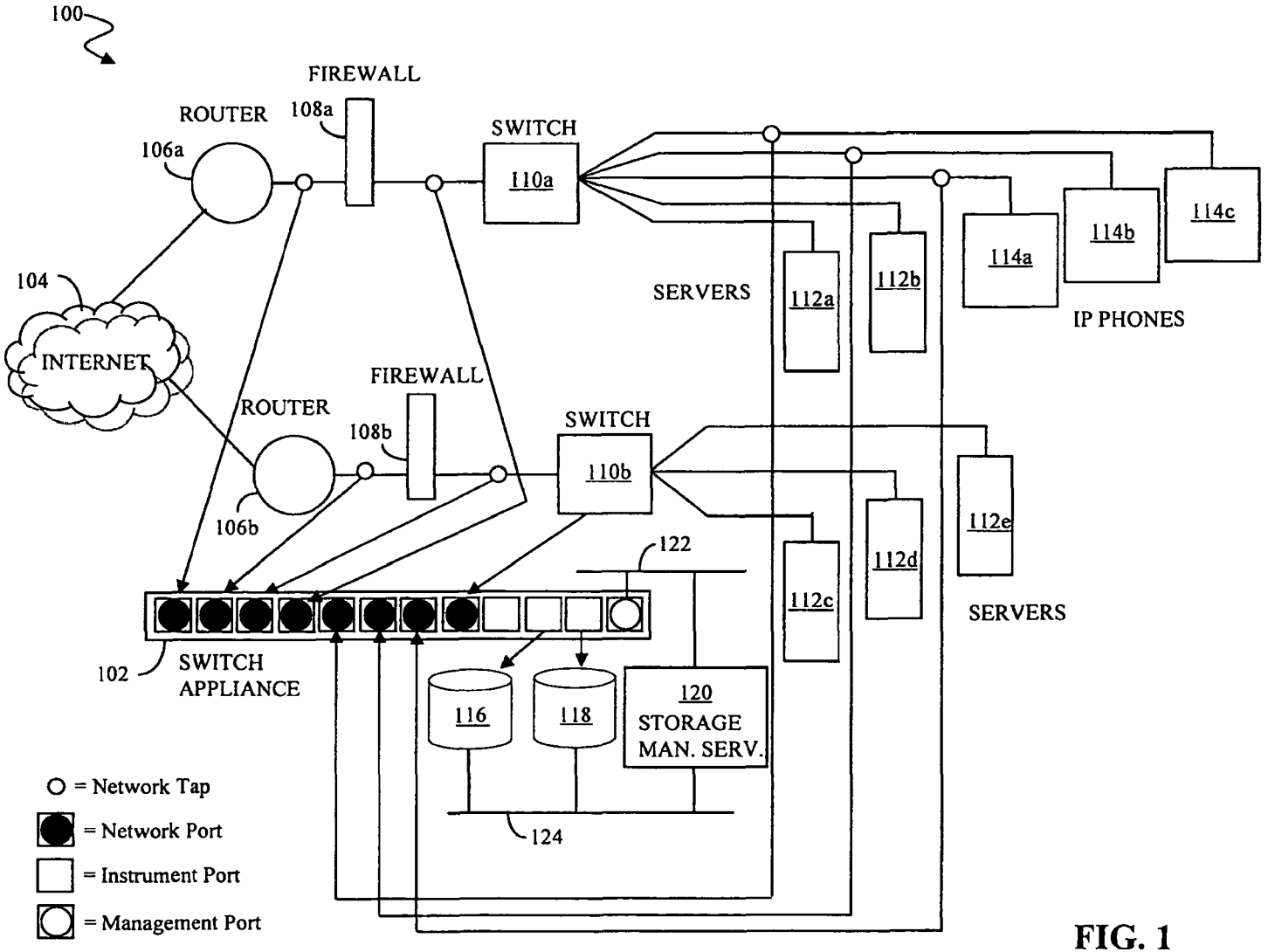

100
FIREWALL
ROUTER
108a
106a
SWITCH
110a
104
INTERNET
SERVERS
112a
112b
114a
114b
114c
IP PHONES
FIREWALL
ROUTER
108b
SWITCH
110b
106b
122
112c
112d
112e
SERVERS
102
SWITCH
APPLIANCE
116
118
120
STORAGE
MAN. SERV.
124
O = Network Tap
= Network Port
= Instrument Port
= Management Port

FIG. 1

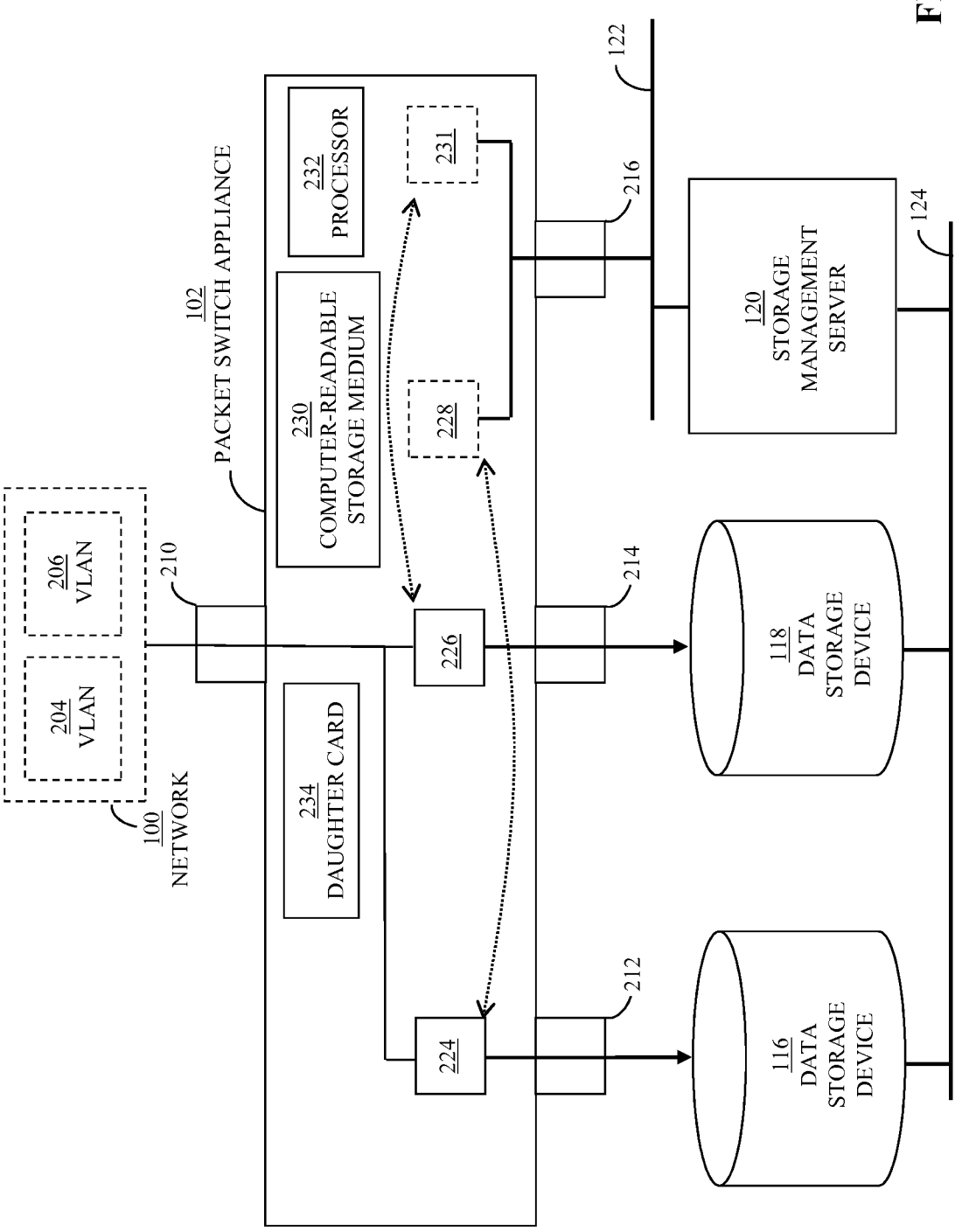

100
NETWORK
204
VLAN
206
VLAN
210
102
PACKET SWITCH APPLIANCE
230
COMPUTER-READABLE
STORAGE MEDIUM
232
PROCESSOR
231
228
226
224
234
DAUGHTER CARD
214
212
216
122
120
STORAGE
MANAGEMENT
SERVER
124
118
DATA
STORAGE
DEVICE
116
DATA
STORAGE
DEVICE

FIG. 2

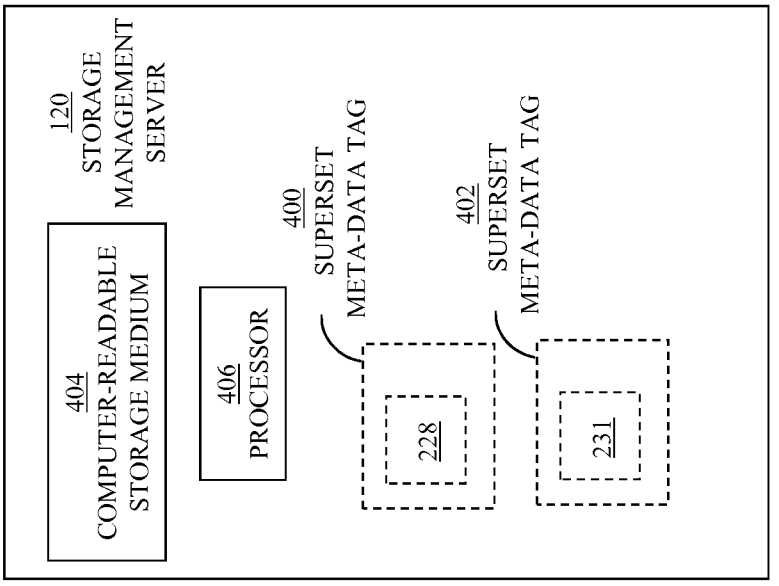

120
STORAGE MANAGEMENT SERVER
404
COMPUTER-READABLE STORAGE MEDIUM
406
PROCESSOR
400
SUPERSET META-DATA TAG
228
402
SUPERSET META-DATA TAG
231

FIG. 4

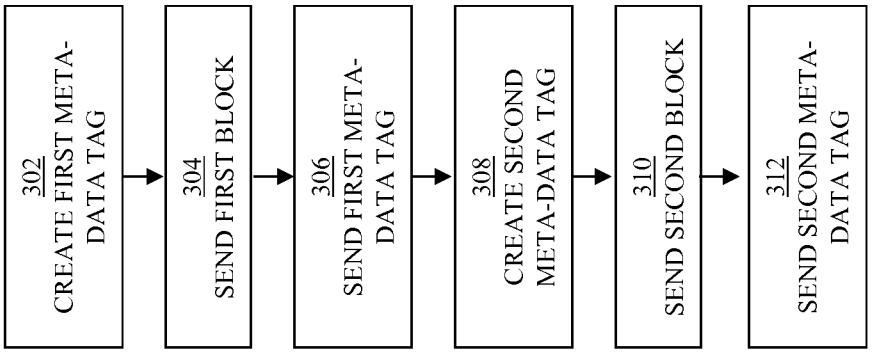

302
CREATE FIRST META-DATA TAG
304
SEND FIRST BLOCK
306
SEND FIRST META-DATA TAG
308
CREATE SECOND META-DATA TAG
310
SEND SECOND BLOCK
312
SEND SECOND META-DATA TAG

FIG. 3

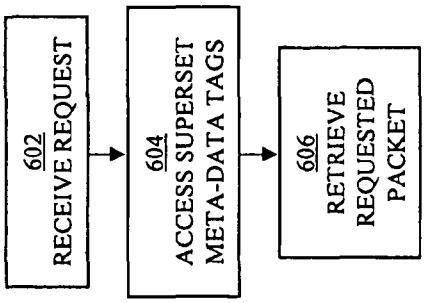

602
RECEIVE REQUEST
604
ACCESS SUPERSET META-DATA TAGS
606
RETRIEVE REQUESTED PACKET

FIG. 6

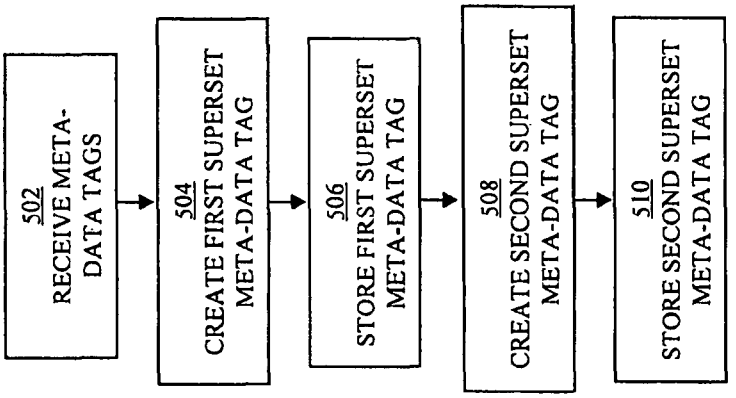

502
RECEIVE META-DATA TAGS
504
CREATE FIRST SUPERSET META-DATA TAG
506
STORE FIRST SUPERSET META-DATA TAG
508
CREATE SECOND SUPERSET META-DATA TAG
510
STORE SECOND SUPERSET META-DATA TAG

FIG. 5

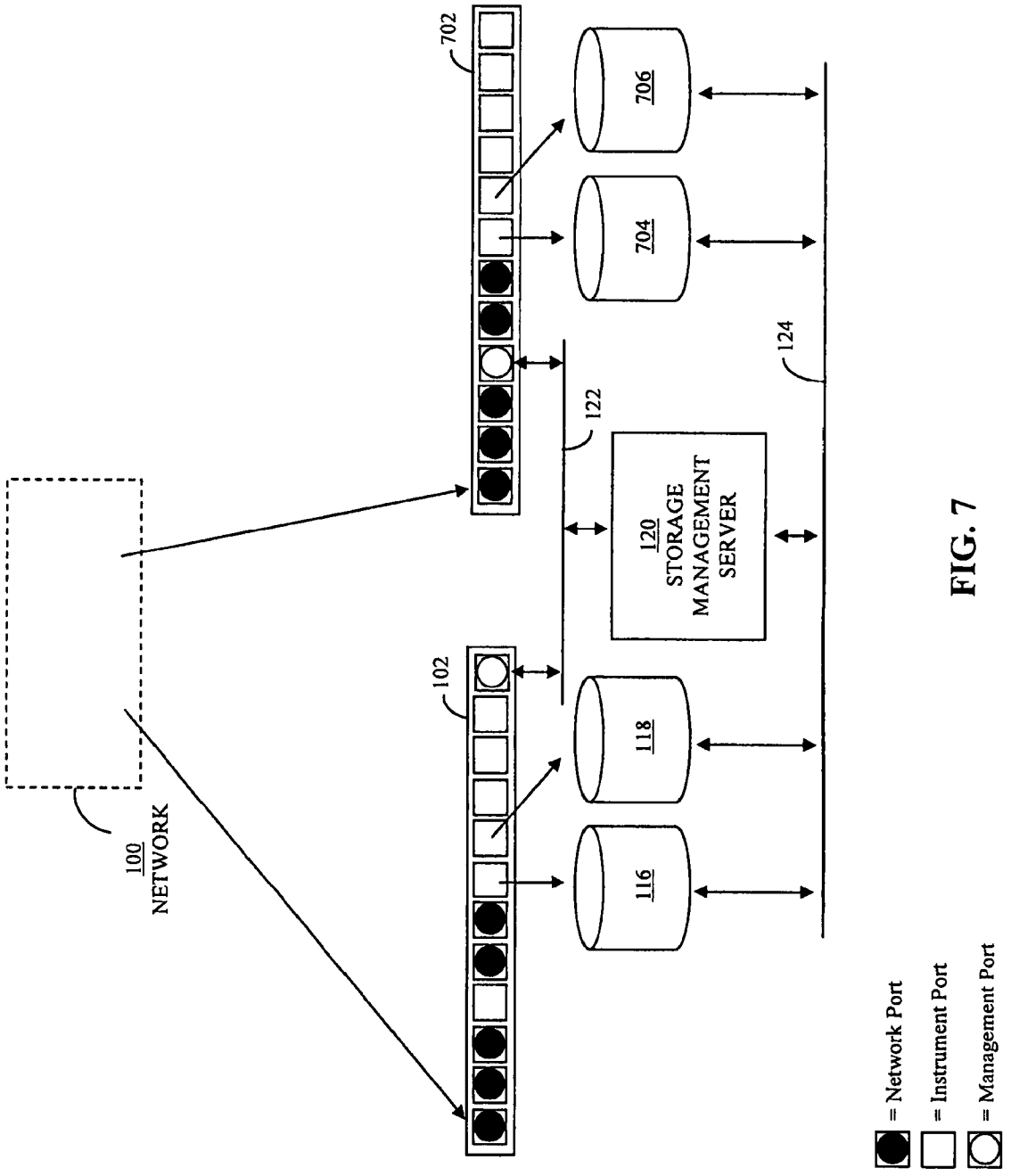

100
NETWORK
102
702
706
704
118
116
122
124
120
STORAGE
MANAGEMENT
SERVER
= Network Port
= Instrument Port
= Management Port

FIG. 7

# CREATING AND/OR MANAGING META-DATA FOR DATA STORAGE DEVICES USING A PACKET SWITCH APPLIANCE

## RELATED APPLICATION DATA

This application is a continuation of U.S. patent application Ser. No. 11/933,239, filed on Oct. 31, 2007, the entire disclosure of which is expressly incorporated by reference herein.

## BACKGROUND

1. Field

The present application relates generally to data storage devices; more specifically, this application relates to creating and/or managing meta-data for data storage devices using a packet switch appliance.

2. Related Art

In a packet-switching network, the transmission, routing, forwarding, and the like of messages between the terminals in the packet-switching network are broken into one or more packets. Typically, data packets transmitted or routed through the packet-switching network comprise three elements: a header, a payload, and a trailer. The header may comprise several identifiers such as source and destination terminal addresses, virtual local area network (VLAN) tag, packet size, packet protocol, and the like. The payload is the core data for delivery, other than header or trailer, which is being transmitted. The trailer typically identifies the end of the packet and may comprise error checking information. Data packets may conform to a number of packet formats such as IEEE 802.1D or 802.1Q.

Associated with each terminal in the packet-switching network is a unique terminal address. Each of the packets of a message has a source terminal address, a destination terminal address, and a payload, which contains at least a portion of the message. The source terminal address is the terminal address of the source terminal of the packet. The destination terminal address is the terminal address of the destination terminal of the packet. Further, each of the packets of a message may take different paths to the destination terminal, depending on the availability of communication channels, and may arrive at different times. The complete message is reassembled from the packets of the message at the destination terminal. One skilled in the art commonly refers to the source terminal address and the destination terminal address as the source address and the destination address, respectively.

A typical packet-switching network employs a packet switch appliance to forward packets within the network to their respective destination terminals. A packet switch appliance may also be employed as part of a network monitoring system of a packet-switching network. The typical packet-switching appliance may include a number of ports. A given port may be configured as a network port for connection to the packet-switching network. Alternatively, a port may be configured as an instrument port for connection to one or more network instruments such as packet sniffers, intrusion detection systems, intrusion prevention systems, forensic recorders, or data storage devices.

Packet traffic in a packet-switching network, or portions thereof, may be stored for later forensic analysis or use. However, a typical packet, with its format of header, payload, and trailer designed for bandwidth efficiency provides limited network information beyond the source and destination address of a given packet. Methods and systems that may provide additional information on packet traffic in a packet-switching network may provide useful information for later retrieval or use.



## SUMMARY

In one exemplary embodiment, a first instrument port of a packet switch appliance is connected to a first data storage device. A second port is configured as a first network port. A first meta-data tag is created for a first block of packets received through the first network port. The first block is sent to the first data storage device through the first instrument port. The first meta-data tag or a copy is sent to the first data storage device and/or a storage management server with the port number of the first instrument port. A second instrument port of the packet switch appliance is connected to a second data storage device. A second meta-data tag is created for a second block of packets received through the first network port. The second block is sent to the second data storage device through the second instrument port. The second meta-data tag or a copy is sent to the second data storage device and/or the storage management server with the port number of the second instrument port.

## DESCRIPTION OF DRAWING FIGURES

The present application can be best understood by reference to the following description taken in conjunction with the accompanying drawing figures, in which like parts may be referred to by like numerals:

FIG. **1** illustrates an exemplary packet-switching network and a packet switch appliance;

FIG. **2** illustrates an exemplary distributed packet storage system;

FIG. **3** is a flow chart of an exemplary process of managing meta-data for data storage devices;

FIG. **4** illustrates an exemplary storage management server for use in distributed packet storage system;

FIG. **5** is a flow chart of an exemplary process of storing meta-data on the storage management server of FIG. **4**;

FIG. **6** is a flow chart of an exemplary process of retrieving a packet using the storage management server of FIG. **4**; and

FIG. **7** illustrates an exemplary distributed packet storage system using multiple packet switch appliances.

## DETAILED DESCRIPTION

The following description sets forth numerous exemplary configurations, parameters, and the like. It should be recognized, however, that such description is not intended as a limitation on the scope of the present invention, but is instead provided as a description of exemplary embodiments.

A. Network Configuration

With reference to FIG. **1**, in one exemplary embodiment, a packet switch appliance **102** is integrated into a packet-switching network **100**. The internet **104** can be connected via routers **106***a* and **106***b* and firewalls **108***a* and **108***b* to switches **110***a* and **110***b*. Switch **110***a* can also be connected to servers **112***a* and **112***b* and to IP phones **114***a-c*. Switch **110***b* can also be connected to servers **112***c-e*. Packet switch appliance **102** can be connected to various points of the network via network taps and tap ports on the packet switch appliance. Packet switch appliance **102** can also be connected to a variety of network instruments, such as data storage devices **116**, **118** and storage management server **120**. It should be recognized that the system depicted in FIG. **1** can

include fewer components or more components than those depicted, and the connection of the packet switch appliance to the network may be varied.

In the embodiment of FIG. **1**, because packet switch appliance **102** is connected to every device in the packet-switching network, the packet switch appliance has a global network footprint and may potentially access all data packets transmitted across the network. Consequently, packet switch appliance **102** is capable of forwarding any or all of the data packets transmitted across the network to data storage devices **116** and **118** for storage and later retrieval.

For the sake of simplicity, packet-switching network **100** is described below in the context of using an Ethernet format. It should be recognized, however, that packet-switching network **100** can use any desirable networking format, such as synchronous optical network (SONET), synchronous digital hierarchy (SDH), wide area network (WAN) protocol, Fiber Channel, and the like.

B. Packet Switch Appliance and Meta Data Creation

The packet switch appliance **102** of FIG. **1** includes a plurality of ports. Each port may be configured as a network port or tap port for connection to the network. Typically, a network port is connected to a network tap or switch of the network. A port of the packet switch appliance may also be configured as an instrument port, which is used for connecting to a network instrument. Packet switch appliance **102** also includes one or more management ports. Typically, an instrument port is limited to one-way traffic, while a management port permits two-way traffic.

In the embodiment of FIG. **1**, data storage device **116** and data storage device **118** are connected to packet switch appliance **102** via instrument ports. Alternative or additional network instruments may include, but are not limited to, network monitoring instruments such as packet sniffers, intrusion detection systems, or the like. A port may also be configured as a transport port for connection between packet switch appliance **102** and another packet switch appliance. Typically, each port of the network switch appliance will have an associated port number or address for identifying the port.

In the embodiment of FIG. **1**, storage management server **120** is connected to packet switch appliance **102** via a management port and to data storage devices **116**, **118**. In particular, storage management server **120** is depicted as being connected to the management port on packet switch appliance **102** through a network **122** and to data storage devices **116**, **118** through a network **124**. Thus, storage management server **120** and data storage devices **116**, **118** can communicate together without necessarily having to communicate through packet switch appliance **102**. In particular, as mentioned above, instrument ports are typically limited to one-way traffic. Thus, data storage devices **116**, **118** can not communicate with storage management server **120** through the instrument ports on the packet switch appliance **102** to which they are connected. Instead, data storage devices **116**, **118** can communicate with storage management server **120** through network **124**, which allows for two-way traffic. Also, while storage management server **120** could communicate with data storage devices **116**, **118** through the management port on the packet switch appliance **102** to which it is connected, it may be preferable in some circumstances for storage management server **120** to communicate with data storage devices **116**, **118** through network **122** rather add traffic on packet switch appliance **102** by using the management port.

In the present exemplary embodiment, network **122** and network **124** are separate from network **100**. Network **122** and/or network **124** can be a private or public network. Network **122** can also be a dedicated or non-dedicated network. Network **122** and network **124** can be connected together as a single network. Also, storage management server **120** can be directly connected to packet switch appliance **102** and/or to data storage devices **116**, **118**.

Packet switch appliance **102** is capable of forwarding received network packet traffic to data storage devices **116** and **118**. The packet switch appliance may forward the packet traffic with or without generating meta-data relating to the forwarded packet traffic data. Meta-data is understood to be any data that provides data about other data, such as the forwarded packet traffic. Meta-data includes, but is not limited to, data concerning the source, destination, time of transmission or receipt, or content of a packet or block of packets. In the instances when meta-data is generated, it may be forwarded to the same destination as the packet traffic, or the meta-data may be forwarded to an alternative destination. Generation of meta-data may be useful in a system employing distributed storage, in which packet data may be stored on more than one data storage device. Meta-data and distributed storage may also be useful in a system in which system resources during retrieval operations may be limited, whereas system resources during storage operations are available.

As depicted in FIG. **2**, packet switch appliance **102** includes a computer-readable storage medium **230**, one or more processor units **232**, and a daughter card **234**. As described below, computer-readable storage medium **230** can include computer-executable instructions to control the operation of packet switch appliance **102**. One or more processor units **232** can execute the instructions stored on computer-readable storage medium **230**. One or more processor units **232** can be configured to perform packet analysis, packet traffic analysis, and meta-data generation. One or more processor units **232** may each be a general purpose processor, a FPGA (field programmable gate array), NPU (network processor unit), multi-core processor, multi-core packet processor, ASIC (application specific integrated circuit), or the like.

Daughter card **234** can include one or more processing units to perform packet analysis, packet traffic analysis, and meta-data generation. The one or more processing units on daughter card **234** can also perform packet modification functions such as packet slicing and packet regeneration based on header, payload, trailer, or other packet information. The one or more processor units on daughter card **234** may each be a general purpose processor, an FPGA, NPU, multi-core processor, multi-core packet processor, ASIC, or the like. For a more detailed description of packet modification functions and additional packet switch appliance hardware, see U.S. patent application Ser. No. 11/796,001, filed on Apr. 25, 2007, which is incorporated herein by reference in its entirety for all purposes.

It should be recognized that packet switch appliance **102** may be configured with additional hardware and/or software and may be capable of additional operations. The packet switch appliance may be configured to perform a number of packet distribution and handling functions such as one-to-one, one-to-many, many-to-one, and many-to-many port distributing, filtering, flow-based streaming, and load balancing. For a more detailed description of these features, see U.S. patent application Ser. Nos. 11/123,273; 11/123,377; 11/123,465; and 11/123,729, all of which were filed on May 5, 2005, and which are all incorporated herein by reference in their entireties for all purposes.

C. Managing Meta-Data

FIG. **2** depicts a system for the distributed storage of packet traffic from packet switched network **100** received by packet switch appliance **102**. The system of FIG. **2** can operate as a

distributed data storage system: packet traffic from network **100** intended for storage is forwarded by packet switch appliance **102** to an array of data storage devices for archiving and, potentially, later retrieval. For example, FIG. **2** depicts packet switch appliance **102** connected to data storage devices **116** and **118**. It should be recognized, however; that packet switch appliance **102** can be connected to any number of data storage devices.

Distributed data storage may provide a number of benefits. Hardware limitations, such as disk write times, may be overcome by distributing the write tasks across a number of instruments. Similarly, single port bandwidth limitations may be overcome by distributing data flow from the packet switch appliance to the array of data storage devices over an array of instrument ports. Upon data retrieval, read operations may realize similar benefits from distributed storage. Physical segregation may also be achieved in that a designated subset of network traffic may be stored on one data storage device while another subset is stored on a separate device, in the same or separate locations.

FIG. **3** depicts an exemplary process of managing meta-data for data storage devices using the packet switch appliance. It should be recognized that the exemplary process depicted in FIG. **3** can be implemented as instructions stored on a computer-readable storage medium in the packet switch appliance. For example, in FIG. **2**, the instructions can be stored on computer-readable medium **230**. Processor **232** can execute the instructions stored on computer-readable medium **230**.

A first port on the packet switch appliance is configured to operate as a first instrument port connected to a first data storage device. As described above, ports of the first data storage device are associated with port numbers. A second port on the packet switch appliance is configured as a first network port connected to the packet-switching network. For example, in FIG. **2**, port **212** on packet switch appliance **102** is configured to operate as a first instrument port connected to data storage device **116**. Assume for the sake of example that port **212** is associated with port number **1**. It should be recognized that this association is a logical association. Port **210** on packet switch appliance **102** is configured as a first network port connected to packet-switching network **100**.

With reference to FIG. **3**, in step **302**, when a first block of one or more packets is received from the packet-switching network through the first network port, a first met-data tag is created for the first block. The first block may include one or more packets that may be modified by the packet switch appliance prior to storage. Packet modification may include, but is not limited to, additions or deletions to components of a packet, such as packet slicing or packet time stamping. For example, it may be found useful to store only the payload or header of packets in a block of packets. The meta-data tag created for the block may provide information about the block of packets such as data concerning the source, destination, time of transmission or receipt, or content of a packet or block of packets. The meta-data tag may also include data concerning the payload of packets in the block.

For example, FIG. **2** depicts block **224** received from packet-switching network **100** through port **210**. Meta-data tag **228** is created for block **224**.

With reference again to FIG. **3**, in step **304**, the first block of one or more packets is sent to the first data storage device through the first instrument port. For example, in FIG. **2**, block **224** is sent to data storage device **116** through port **212**.

With reference again to FIG. **3**, in step **306**, the first meta-data tag or a copy of the first meta-data tag is sent. In one exemplary embodiment, the first meta-data tag or a copy of the first meta-data tag is sent to data storage device **116**. In another exemplary embodiment, the first meta-data tag or a copy of the first meta-data tag is sent to a storage management server. The first meta-data tag or the copy of the first meta-data tag is sent to the storage management server with the port number associated with the first instrument port, which was the port through which the first block was sent to the first data storage device.

Note, if the meta-data tag is sent to data storage device **116**, then a copy of the first meta-data tag is sent to the storage management server. Alternatively, if a copy of the first meta-data tag is sent to data storage device **116**, then the meta-data tag or another copy of the first meta-data tag is sent to the storage management server.

For example, in FIG. **2**, storage management server **120** is connected to packet switch appliance **102** through management port **216**. Meta-data tag **228** or a copy of meta-data tag **228** is sent to storage management server **120** through management port **216**. Assume that port **212** is associated with port number **1**. Thus, meta-data tag **228** or copy of meta-data tag **228** includes port number **1**. Meta-data tag **228** or copy of meta-data tag **228** can also include information about what types of packets are in block **224**, IP addresses (such as source and destination IP addresses, source and destination MAC addresses, source and destination app ports, etc.), MAC addresses (such as special multicast MAC addresses, specific MAC addresses of servers or honey pots, etc.), protocol types, a unique identification for packet switch appliance **102** (such as a unique system serial number), one or timestamps on when block **224** first started to fill and when block **224** became full or closed, the size of block **224**, etc. Meta-data tag **228** or copy of meta-data tag **228** can also include various other types of information, such as names of any switch and span ports that are sourcing the data to packet switch appliance **102**.

It should be recognized that some of the information in meta-data tag **228** or copy of meta-data tag **228** may not be directly extractable from the packets. The user can configure such information to packet switch appliance **102**, such as the information about which span port is sending data to network port **210**.

In the present exemplary embodiment, a third port on the packet switch appliance is configured to operate as a second instrument port connected to a second data storage device. For example, in FIG. **2**, port **214** on packet switch appliance **102** is configured to operate as a second instrument port connected to data storage device **118**. Assume for the sake of example that port **214** is associated with port number **2**.

With reference again to FIG. **3**, in step **308**, when a second block of one or more packets is received from the packet-switching network through the first network port, a second met-data tag is created for the second block. For example, FIG. **2** depicts block **226** received from packet-switching network **100** through port **210**. Meta-data tag **231** is created for block **226**.

With reference again to FIG. **3**, in step **310**, the second block of one or more packets is sent to the second data storage device through the second instrument port. For example, in FIG. **2**, block **226** is sent to data storage device **118** through port **214**.

With reference again to FIG. **3**, in step **312**, the second meta-data tag or a copy of the second meta-data tag is sent. In one exemplary embodiment, the second meta-data tag or a copy of the second meta-data tag is sent to data storage device **118**. In another exemplary embodiment, the second meta-data tag or the copy of the second meta-data tag is sent to a storage management server. The second meta-data tag or the

copy of the second meta-data tag is sent to a storage management server with the port number associated with the second instrument port, which was the port through which the second block was sent to the second data storage device.

Note, if the meta-data tag is sent to data storage device **118**, then a copy of the first meta-data tag is sent to the storage management server. Alternatively, if a copy of the first meta-data tag is sent to data storage device **118**, then the meta-data tag or another copy of the first meta-data tag is sent to the storage management server.

For example, in FIG. **2**, meta-data tag **231** or copy of meta-data tag **231** is sent to storage management server **120** through management port **216**. Assume that port **214** is associated with port number **2**. Again, it should be recognized that this associate is a logical association. Thus, meta-data tag **231** or copy of meta-data tag **231** includes port number **2**. Meta-data tag **231** or copy of meta-data tag **231** can also include information about what types of packets are in block **226**, IP addresses (such as source and destination IP addresses, source and destination MAC addresses, source and destination app ports, etc.), MAC addresses (such as special multicast MAC addresses, specific MAC addresses of servers or honey pots, etc.), protocol types, a unique identification for packet switch appliance **102** (such as a unique system serial number, one or timestamps on when block **226** first started to fill and when block **226** became full or closed, the size of block **226**, etc. Meta-data tag **231** or copy of meta-data tag **231** can also include various other types of information, such as names of any switch and span ports that are sourcing the data to packet switch appliance **102**.

It should be recognized that some of the information in meta-data tag **231** or copy of meta-data tag **231** may not be directly extractable from the packets, but the user can configure such information to packet switch appliance **102**. For example, the information about which span port is sending data to network port **210**.

In one exemplary embodiment, another port on packet switch appliance **102** can be configured to operate as a second network port connected to network **100**. When a third block of one or more packets is received through the second network port, a third meta-data tag can be created for the third block. The third block is sent to first data storage device **116** through the first instrument port. The third meta-data tag or a copy of the third meta-data tag is sent to storage management server **120** with the port number associated with the first instrument port. When a fourth block of one or more packets is received through the second network port, a fourth meta-data tag can be created for the fourth block. The fourth block is sent to second data storage device **116** through the second instrument port. The fourth meta-data tag or a copy of the fourth meta-data tag is sent to storage management server **120** with the port number associated with the second instrument port. It should be recognized that packet switch appliance **102** can include any number of ports configured to operate as network ports.

In one exemplary embodiment, packet switch appliance **102** can be used to filter and/or parse packets received from the packet-switching network through the first network port using one or more criteria. In one implementation, a filter associated with network port **210** can filter packets into one or more blocks. The filter can also tag the filtered packets with information bits, which can be used to create meta-data tags. The meta-data tags can then be appended to the one or more blocks. In another implementation, the filter can filter the packets into one or more blocks without tagging the filtered packets. The filtered packets are parsed based on one or more criteria to create meta-data tags. The meta-data tags can then be appended to the one or more blocks. In still another implementation, the filter can filter the packets into one or more blocks, and also tag the filtered packets. Meta-data tags can be created using the tags. The filtered packets can then be further parsed based on one or more criteria to create meta-data tags. The meta-data tags are appended to the one or more blocks.

The one or more criteria can include a VLAN identification of the packet, source address, destination address, type of data, etc. Thus, in one exemplary embodiment, packet switch appliance **102** can be used in managing data received from virtual local area networks. For example, FIG. **2** depicts VLANs **204** and **206**. Each VLAN can be a logical association of similar devices: IP phones, servers, and workstations, respectively. Each VLAN can also be a logical association of users that may or may not be physically associated. Block **224** can include all packets associated with VLAN **204** received in a specified time period if block **224** has not filled up by the end of that time period. For example, when VLAN **204** includes all IP phones, block **224** would include all IP phone-associated packets trafficking on network **100** for the specified time period. Similar, block **226** can include all packets associated with VLAN **206** received in a specified time period if block **226** has not filled up by the end of that time period. For example, when VLAN **206** includes all servers, block **226** would include all server-associated packets trafficking on network **100** for the specified time period.

FIG. **5** depicts an exemplary process of storing meta-data on the storage management server. It should be recognized that the exemplary process depicted in FIG. **5** can be implemented as instructions stored on a computer-readable storage medium in the packet switch appliance. For example, in FIG. **4**, the instructions can be stored on computer-readable medium **404** of storage management server **120**. Processor **406** can execute the instructions stored on computer-readable medium **404**.

With reference again to FIG. **5**, in step **502**, the first and second meta-data tags or copies of the first and second meta-data tags are received. In step **504**, a first superset meta-data tag is created for the first meta-data tag or copy of the first meta-data tag. In step **506**, the first superset meta-data tag is stored. In step **508**, a second superset meta-data tag is created for the second meta-data tag or copy of the second meta-data tag. In step **510**, the second superset meta-data tag is stored. For example, in FIG. **4**, superset meta-data tag **400** is generated for meta-data tag **228**. Superset meta-data tag **402** is generated for meta-data tag **231**. It should be recognized that a superset meta-data tag can be created for any number of meta-data tags.

A superset meta-data tag can include information, such as unique identifications for the data storage devices attached to the instrument ports of the packet switch appliance, identifications of network devices or elements that are the sources of packets received from the packet-switching network through the instrument port of the packet switch appliance, etc.

A superset meta-data tag can be used to facilitate a request for a packet or packets. FIG. **6** depicts an exemplary process of retrieving a packet using the superset meta-data tags generated by the storage management server. It should be recognized that the exemplary process depicted in FIG. **6** can be implemented as instructions stored on a computer-readable storage medium in the packet switch appliance. For example, in FIG. **4**, the instructions can be stored on computer-readable medium **404** of storage management server **120**. Processor **406** can execute the instructions stored on computer-readable medium **404**.

With reference again to FIG. **6**, in step **602**, a request for a packet or packets meeting one or more criteria is received. In

step **604**, the superset meta-data tags are accessed to identify a meta-data tag or copy of a meta-data tag associated with a block of one or more packets with data satisfying the one or more criteria. In step **606**, the requested packet is retrieved using the port number obtained from the identified meta-data tag or copy of the first meta-data tag.

In one exemplary embodiment, the association between port numbers and unique identifications for data storage devices is stored. For example, with reference to FIG. **2**, an association between the port number of instrument port **212** and the unique identification for data storage device **116** is stored. An association between the port number of instrument port **214** and the unique identification for data storage device **118** is stored. The unique identification for a data storage device can include model number, serial number input port number, NIC's ID, storage capacity, connect and disconnect time with the port on packet switch appliance **102**, etc.

The stored association between port numbers and unique identifications for data storage devices can be used in retrieving the requested packet. In particular, as described below with reference to step **606** (FIG. **6**), the requested packet is retrieved using the port number obtained from the identified meta-data tag or copy of the first meta-data tag. The stored association between port numbers and unique identifications can be used to identify the unique identification for the data storage device associated with the port number obtained from the identified meta-data tag or copy of the first meta-data tag in step **606** (FIG. **6**). The unique identification number for the data storage device can then be used to retrieve the requested packet from the data storage device. For example, with reference to FIG. **2**, once the unique identification number for data storage device **116** or **118** is known, storage management server **120** can communicate with data storage device **116** or **118** through network **124** to retrieve the requested packet from data storage device **116** or **118**.

The association between port numbers and unique identifications for data storage devices can be stored at various locations. For example, the association can be stored at packet switch appliance **102**, storage management server **120**, or another device that is accessible to storage management server **120**. If the association between port numbers and data storage devices changes, the stored association is updated. For example, if instrument port **214** is connected to a data storage device other than data storage device **118**, then the stored association between port numbers and unique identifications for data storage devices is updated to reflect that new association between the port number of instrument port **214** and the new data storage device.

With reference again to FIG. **2**, in one exemplary embodiment, the distributed packet storage system can be configured with availability or performance assessment, and/or performance compensation capabilities. For example, data storage devices **116** and **118** may be configured with logic and/or hardware for detecting a reduction in availability or performance, such as a reduction in storage capacity, resource availability, or storage performance. Data storage devices **116** and **118** can also be configured to send a command to storage management server **120**, which will then communicate any desired changes to packet switch appliance **102** upon detection of a predetermined level of reduction in availability or performance.

In one exemplary embodiment, upon receiving a signal of reduced availability or performance from storage management server **120** and appropriate commands, packet switch appliance **102** can be configured to re-route blocks of packets designated for the data storage device to another data storage device. For example, assume a signal of reduced availability or performed is received from data storage device **116** by storage management server **120**, storage management server **120** can command packet switch appliance **102** to re-route blocks of packets designated for data storage device **116** to data storage device **118**.

In one exemplary embodiment, packet switch appliance **102** can be configured by storage management server **120** to continue re-routing blocks designated for one data storage device until the data storage device sends a command to storage management server **120** to restore block routing to that data storage device. In another exemplary embodiment, the packet switch appliance **102** or storage management server **120** can be configured to poll data storage devices **116** and **118** at intervals to determine availability or performance of the data storage devices.

In one exemplary embodiment, performance in the distributed packet storage system can also be assessed via timestamping. For example, packet switch appliance **102** can generate a time stamp packet when a block of packets is first received by packet switch appliance **102**. A second timestamp packet is generated by packet switch appliance **102** prior to sending the block of packets through an instrument port. Thus, two time stamped packets, separated by a time interval, are generated.

Performance at various points in the system of FIG. **2** may be assessed based on a comparison of the timestamps. For example, performance of packet switch appliance **102** can be assessed by analyzing the time from packet receipt to packet forwarding using the two time stamped packets described above. The performance of data storage device **116** can be assessed by analyzing the time interval between the storage of the first time stamped packet and the second time stamped packet.

In one exemplary embodiment, multiple packet switch appliances, as described herein, may be employed in a distributed packet storage system. For example, FIG. **7** depicts a distributed packet storage system with packet switch appliances **102** and **702**. It should be recognized, however, that the distributed packet storage system can include any number of packet switch appliances.

Similar to packet switch appliance **102**, packet switch appliance **702** can be configured to create and manage meta-data for data storage devices. In particular, a first port on packet switch appliance **702** can be configured to operate as a first instrument port connected to data storage device **704**. A second port on packet switch appliance **702** can be configured to operate as second instrument port connected to data storage device **706**. It should be recognized that packet switch appliance **702** can be connected to any number of data storage devices.

A third port on packet switch appliance **702** can be configured to operate as a first network port connected to packet-switching network **100**. When a block of one or more packets is received from packet-switching network **100** through the first network port on packet switch appliance **702**, a meta-data tag for the block is created. The block of one or more packets is sent to data storage device **704** through the first instrument port. The meta-data tag or a copy of the meta-data tag is sent to storage management server **120**. The meta-data tag or the copy of the meta-data tag includes the port number associated with the first instrument port through which the block was sent to data storage device **704**.

Note, the original meta-data tag can be included in the block of one or more packets sent to data storage device **704**, and the copy of the meta-data tag can be sent to storage management server **120**. Alternatively, the original meta-data tag can be sent to storage management server **120**, and the

copy of the meta-data tag can be included in the block of one or more packets sent to data storage device **704**. As another alternative, the copy of the meta-data tag can be sent to storage management server **120**, and another copy of the meta-data tag can be included in the block of one or more packets sent to data storage device **704**.

As depicted in FIG. **7**, storage management server **120** and packet switch appliances **102**, **702** can be connected through network **122**. In particular, storage management server **120** is connected to network **122**, and packet switch appliances **102** and packet switch appliance **702** are connected to network **122** through management ports on the packet switch appliance.

In one exemplary embodiment, different packet switch appliances can be assigned to handle different sets of packets from network **100**. For example, in FIG. **7**, packet switch appliance **102** can be assigned to handle a first set of packets from network **100**, such as those associated with a first VLAN, and packet switch appliance **702** can be assigned to handle a second set of packets from network **100**, such as those associated with a second VLAN. It should be recognized that any number of packet switch appliances can be assigned to any number of different set of packets.

In one exemplary embodiment, each packet switch appliance can be assigned a unit number. The meta-data tag or copy of the meta-data tag sent from the packet switch appliance can include the unit number of the packet switch appliance. For example, in FIG. **7**, packet switch appliance **102** can be assigned **1** as a unit number. Thus, the meta-data tag or copy of the meta-data tag sent from packet switch appliance **102** to storage management server **120** includes unit number **1**. Packet switch appliance **702** can be assigned **2** as a unit number. Thus, the meta-data tag or copy of the meta-data tag sent from packet switch appliance **702** to storage management server **120** includes unit number **2**.

Although only certain exemplary embodiments have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention.

We claim:

**1**. A packet switch appliance, comprising:

a first network port for receiving a first packet;

a first instrument port for communication with a first device; and

a processing unit configured to create a first meta-data tag for the first packet;

wherein the first meta-data tag comprises an identifier of the packet switch appliance and information about the first network port at which the first packet is received; and

wherein the processing unit is configured to pass the first meta-data tag to the first instrument port for transmission of the first meta-data tag to the first device.

**2**. The packet switch appliance of claim **1**, further comprising a second network port for receiving a second packet, wherein the processing unit is configured to create a second meta-data tag for the second packet.

**3**. The packet switch appliance of claim **1**, wherein the processing unit is configured to create a second meta-data tag for a second packet.

**4**. The packet switch appliance of claim **3**, further comprising a second instrument port for communication with a second device;

wherein the processing unit is configured to pass the second meta-data tag to the second instrument port for transmission of the second meta-data tag to the second device.

**5**. The packet switch appliance of claim **1**, further comprising a management port for communication with a management node, wherein the management port is configured to both transmit information to, and receive information from, the management node.

**6**. The packet switch appliance of claim **1**, further comprising a transport port for communication with another packet switch appliance.

**7**. The packet switch appliance of claim **1**, wherein the first meta-data tag further comprises a first time stamp and a second time stamp for the first packet.

**8**. The packet switch appliance of claim **1**, wherein the first network port is selectively configurable to function as a network port for packet reception, or an instrument port for packet transmission to a device.

**9**. The packet switch appliance of claim **1**, wherein the processing unit is configured to create the first meta-data tag by filtering the first packet, applying a tag to the filtered packet, and creating the first meta-data tag based on the applied tag.

**10**. The packet switch appliance of claim **1**, wherein the processing unit is configured to filter packets, parse packets, or both filter and parse packets, based on one or more criteria.

**11**. The packet switch appliance of claim **1**, wherein the one or more criteria comprises one or more of a VLAN identification of the packet, a source address, a destination address, and a type of data.

**12**. The packet switch appliance of claim **1**, wherein the packet switch appliance is an out-of-band appliance.

**13**. The packet switch appliance of claim **1**, wherein the first meta-data tag further comprises a first time stamp.

**14**. The packet switch appliance of claim **13**, wherein the first time stamp is associated with an arrival time of the first packet at the packet switch appliance.

**15**. The packet switch appliance of claim **13**, wherein the first time stamp is associated with a departure time of the first packet from the packet switch appliance.

**16**. The packet switch appliance of claim **13**, wherein the first meta-data tag further comprises a second time stamp, wherein the first time stamp is associated with an arrival time of the first packet at the packet switch appliance, and the second time stamp is associated with a departure time of the first packet from the packet switch appliance.

**17**. A network system comprising:

a packet switch appliance having a first network port for receiving a first packet, a first instrument port for communication with a first device, and a processing unit configured to create a first meta-data tag for the first packet, wherein the first meta-data tag comprises an identifier of the packet switch appliance and information about the first network port at which the first packet is received, and wherein the processing unit is configured to pass the first meta-data tag to the first instrument port for transmission of the first meta-data tag to the first device; and

an additional packet switch appliance;

wherein the packet switch appliance comprises a first transport port configured to communicate with the additional packet switch appliance through a second transport port at the additional packet switch appliance.

**18**. The network system of claim **17**, further comprising a management node in communication with both the packet switch appliance and the additional packet switch appliance.

19. The network system of claim 18, wherein the management node has access to a first set of one or more storage devices that are in communication with the packet switch appliance, and a second set of one or more storage devices that are in communication with the additional packet switch appliance.

20. A network system comprising:

a packet switch appliance having a first network port for receiving a first packet, a first instrument port for communication with a first device, and a processing unit configured to create a first meta-data tag for the first packet, wherein the first meta-data tag comprises an identifier of the packet switch appliance and information about the first network port at which the first packet is received, and wherein the processing unit is configured to pass the first meta-data tag to the first instrument port for transmission of the first meta-data tag to the first device;

an additional packet switch appliance;

wherein the packet switch appliance comprises a first management port, the additional packet switch appliance comprises a second management port, and the first and second management ports are configured to communicate with a same management node.

21. The network system of claim 20, further comprising the management node, wherein the management node has access to a first set of one or more storage devices that are in communication with the packet switch appliance, and a second set of one or more storage devices that are in communication with the additional packet switch appliance.

22. A packet switch appliance, comprising:

a first network port for receiving a first packet;

a first instrument port for communication with a first device;

a processing unit configured to create a first meta-data tag for the first packet, and to pass the first meta-data tag to the first instrument port for transmission of the first meta-data tag to the first device; and

a port for communication with an additional packet switch appliance;

wherein the first meta-data tag comprises one or both of an identifier of the packet switch appliance, and information about the first network port at which the first packet is received by the packet switch appliance.

23. A packet switch appliance, comprising:

a first network port for receiving a first packet;

a first instrument port for communication with a first device;

a processing unit configured to create a first meta-data tag for the first packet, and to pass the first meta-data tag to the first instrument port for transmission of the first meta-data tag to the first device; and

a port for communication with an additional packet switch appliance;

wherein the first meta-data tag comprises a first time stamp and a second time stamp for the first packet.

24. A packet switch appliance, comprising:

a first network port for receiving a first packet;

a first instrument port for communication with a first device;

a processing unit configured to create a first meta-data tag for the first packet, and to pass the first meta-data tag to the first instrument port for transmission to the first device, wherein the first meta-data tag includes an identifier of the first instrument port that is for transmission of the first meta-data tag to the first device; and

a port for communication with an additional packet switch appliance.

25. The packet switch appliance of claim 24, wherein the port comprises a transport port dedicated for communication with the additional packet switch appliance.

26. The packet switch appliance of claim 25, wherein the packet switch appliance is arranged with the additional packet switch appliance in a stacked configuration using the transport port.

27. The packet switch appliance of claim 24, wherein the processing unit is configured to create a second meta-data tag for a second packet.

28. The packet switch appliance of claim 27, further comprising a second instrument port for communication with a second device;

wherein the processing unit is configured to pass the first meta-data tag to the first instrument port for transmission to the first device, and to pass the second meta-data tag to the second instrument port for transmission to the second device.

29. The packet switch appliance of claim 24, further comprising a management port for communication with a management node, wherein the management port is configured to both transmit information to, and receive information from, the management node.

30. The packet switch appliance of claim 24, wherein the first network port is selectively configurable to function as a network port for packet reception, or an instrument port for packet transmission to a device.

31. The packet switch appliance of claim 24, wherein the processing unit is configured to create the first meta-data tag by filtering the first packet, applying a tag to the filtered packet, and creating the first meta-data tag based on the applied tag.

32. The packet switch appliance of claim 24, wherein the processing unit is configured to filter packets, parse packets, or both filter and parse packets, based on one or more criteria.

33. The packet switch appliance of claim 24, wherein the one or more criteria comprises one or more of a VLAN identification of the packet, a source address, a destination address, and a type of data.

34. The packet switch appliance of claim 24, wherein the packet switch appliance is an out-of-band appliance.

35. A network system comprising:

a packet switch appliance having a first network port for receiving a first packet, a first instrument port for communication with a first device, a processing unit configured to create a first meta-data tag for the first packet, and to pass the first meta-data tag to the first instrument port for transmission to the first device, wherein the first meta-data tag includes an identifier of the first instrument port that is for transmission of the first meta-data tag to the first device, and a port for communication with an additional packet switch appliance; and

an additional packet switch appliance;

wherein additional packet switch appliance comprises a transport port configured to communicate with the packet switch appliance through the port at the packet switch appliance.

36. The network system of claim 35, further comprising a management node in communication with both the packet switch appliance and the additional packet switch appliance.

37. The network system of claim 36, wherein the management node has access to a first set of one or more storage devices that are in communication with the packet switch

appliance, and a second set of one or more storage devices that are in communication with the additional packet switch appliance.

**38**. A network system comprising:

a packet switch appliance having a first network port for receiving a first packet, a first instrument port for communication with a first device, a processing unit configured to create a first meta-data tag for the first packet, and to pass the first meta-data tag to the first instrument port for transmission to the first device, wherein the first meta-data tag includes an identifier of the first instrument port that is for transmission of the first meta-data tag to the first device, and a port for communication with an additional packet switch appliance;

an additional packet switch appliance;

wherein the packet switch appliance comprises a first management port, the additional packet switch appliance comprises a second management port, and the first and second management ports are configured to communicate with a same management node.

**39**. The network system of claim **38**, further comprising the management node, wherein the management node has access to a first set of one or more storage devices that are in communication with the packet switch appliance, and a second set of one or more storage devices that are in communication with the additional packet switch appliance.

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